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TO: Stetson Engineers

SUBJECT: DRAFT Technical Memorandum
Regional Geology and 3D Geologic Model for the
Santa Ynez River Valley Groundwater Basin

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1. INTRODUCTION

This technical memorandum is prepared as part of the hydrogeologic conceptual model (HCM) for the Western and Central Management Areas (WMA and CMA, respectively) Groundwater Sustainability Agencies[1] (GSAs) within the larger Santa Ynez River Valley Groundwater Basin (SYRVGB). This technical memorandum focuses on the geologic units within the SYRVGB, and the subsurface geologic model built to visualize those units. The aquifer characteristics of these units are then considered in a separate study which correlates principal aquifers within the basin. This technical memo describes the modeled geologic units and existing literature that identifies the water-bearing tendency of each unit but does not include an in-depth principal aquifer analysis or discussion.

The HCM is the conceptual understanding of the physical characteristics related to the regional hydrology, land use, geologic units and structures, groundwater quality, principal groundwater aquifers, and principle aquitards of the WMA and CMA portions of the SYRVGB (basin). Understanding the regional geologic setting and structural configuration is integral to conducting subsequent technical studies of the basin, including presence, absence and correlation of principal aquifers, identification of an appropriate monitoring network, numerical groundwater modeling, and identification of projects and management actions in accordance with the Sustainable Groundwater Management Act (SGMA).

A detailed subsurface three-dimensional model of the geologic units and structures (model) that comprise the basin was developed from publicly available published reports and data sources from the WMA and CMA GSAs. The model is intended for use as a visualization tool to communicate the regional geologic setting to the WMA and CMA GSAs, as well as the public, in accordance with SGMA. Additionally, the model will be used in concert with the Water Budget and the Data Management System to identify potential data gaps within the basin where additional data

[1] This technical memorandum does not include the Eastern Management Area (EMA) GSA within the SYRVGB. The EMA GSA is supported by a different consulting team.

collection may be warranted. Furthermore, model elements may be exported to support subsequent technical studies conducted in the basin for incorporation into a SGMA compliant Groundwater Sustainability Plan (GSP), due to the California Department of Water Resources (DWR) in January of 2022.

The remainder of this technical memorandum describes the geologic data and methodology used to build the model, including quality control methods implemented at the boundary of the CMA and EMA, for alignment with the model built by the EMA consultant team. Representative cross-sections and maps included as figures in this technical memorandum are derived from the model.

1.1 REGIONAL GEOLOGIC SETTING

The regional geology for the basin has been previously described in various publicly available reports. The previous reports contain comprehensive studies and descriptions of the geological formations in and surrounding the WMA and CMA, herein referred to as the basin, when describing the regional geology. The basin is located within the Transverse Range geomorphic province of California (Figure 1), which is characterized by east-west striking, complexly folded and faulted bedrock formations. The basin is an east-west trending, linear, irregular structural depression between rugged mountain ranges and hills within the Transverse Range in Santa Barbara County, CA. The basin is bounded by the Purisima Hills on the northwest, the San Rafael Mountains on the northeast, the Santa Ynez Mountains on the south, and the Pacific Ocean on the west. Primary structural features of the basin include large anticline-syncline pairs. These large folds are evident in the rocks and deposits in the lowland between the folded and faulted Santa Ynez Mountains on the south and the faulted San Rafael Mountains on the north (Upson and Thomasson, 1951). Regional geology is included in a plan view on Figure 2.

Geologic Formations Within the Basin

The geologic formations that comprise the water-bearing aquifers are defined as those with sufficient permeability, storage potential, and groundwater quality to store and convey groundwater. The geologic formations present in the basin are described below under "Geologic Formations." Further discussion of the water bearing characteristics of the aquifers is provided under "Aquifers." Stratigraphic representation of geologic formations included in the model are included in Figures 3 and 4.

Soils

Although not strictly a geologic formation, soils found in the study area are important in that they blanket most of the area, support vegetation, and provide varying degrees of infiltration depending on their characteristics. Soil typically vary with respect to the underlying geologic material. Soils underlain by consolidated deposits tend to be clayey loams, whereas soils underlain by unconsolidated deposits are typically sandy loams (Hydrologic Consultants, Inc., 1997 and references therein). Ultimately, both soils have formed from similar parent material, as the unconsolidated deposits are sourced from the erosion, transport and deposition of the underlying and surrounding consolidated deposits (i.e., shales and sandstones) that comprise the surrounding mountains and hills (Upson and Thomasson, 1951; Hydrologic Consultants, Inc., 1997).

River Channel Deposits (Qg)

Qg occurs within the modern-day Santa Ynez River channel and consists of fine-to-coarse sand, gravels, and thin discontinuous lenses of clay and silt (Upson and Thomasson, 1951; Wilson, 1959; Miller, 1976; Bright et al., 1992). The grain size typically decreases along the river's reach, fining towards the ocean (Upson and Thomasson, 1951). The Qg unit thickness ranges from 30-feet (ft) to 40-ft, with observations of localized deposits up to 70-ft thickness 6 miles west of the City of Buellton along the Santa Ynez River, however, these deposits are largely indistinguishable from the underlying alluvium (Upson and Thomasson, 1951). The Qg in the geologic model is interpreted using the Dibblee geologic map and from borehole data and is generally thought to be hydraulically connected to the Qa, described below.

Alluvium (fluvial-Qa)

Qa is composed of a coarse sand upper member and a fine sand lower member which have been previously described by others (Dibblee, 1950; Upson and Thomasson, 1951; Wilson, 1959; Miller, 1976; Bright et al., 1992). For the purposes of the geologic model described in Section 1.2 below, these units are not differentiated, and the alluvium was modeled as a single lithologic unit. Qa is composed of unconsolidated, normally graded gravel and medium-to-very coarse sand, which grades upwards into fine to coarse sand with rare gravels, then fines vertically upwards into fine sand, silt and clay (Upson and Thomasson, 1951; Wilson, 1959; Miller, 1976; Bright et al., 1992; Fugro Consultants, INC., 2014). The thickness of Qa varies from approximately 30 to 90-ft in the Buellton Subarea (Upson and Wilson, 1951) to approximately 170-ft to 200-ft in the Lompoc plain (Dibblee, 1950; Upson and Thomasson, 1951; Evenson and Miller, 1963; Miller, 1976; Bright et al., 1992). In sloped areas and drainages, the thickness of Qa varies from less than 10-ft to 50-ft (Fugro Consultants, INC., 2014). Qa is the principal source of groundwater in the Lompoc plain (Dibblee, 1950; Upson and Thomasson, 1951; Evenson and Miller, 1963; Miller, 1976; Berenbrock, 1988; Bright et al., 1992).

Terrace Deposits / Older Alluvium (fluvial-Qoa)

Qoa typically consists of unconsolidated to poorly consolidated sands and gravels with common silt and clay zones (Dibblee, 1950; Upson and Thomasson, 1951; Miller, 1976; Berenbrock, 1988; Bright et al., 1992). Qoa thickness varies from 0-50-ft (Bright et al., 1992), up to 150-ft (Upson and Thomasson, 1951; Miller, 1976; Berenbrock, 1988). Qoa underlies alluvium (Qa) in most of the southern Lompoc plain and caps hilltops, benches and upland areas of the Santa Ynez River and major tributaries (Upson and Thomasson, 1951; Miller, 1976; Berenbrock, 1988; Bright et al., 1992).

Orcutt Sand (eolian / nonmarine- Qo)

Qo consists of unconsolidated, well sorted, coarse to medium sand and clayey sand with scattered pebbles and gravel stringers (Upson and Thomasson, 1951; Bright et al., 1992). The top of the formation is locally indurated in Lompoc Valley and Burton Mesa by iron oxides, whereas the basal portion contains well-rounded pebbles of quartzite, igneous rocks, and Monterey chert and shale (Dibblee, 1950). Qo thickness varies from 0-300-ft (Upson and Thomasson, 1951; Evenson and Miller, 1963; Bright et al., 1992).

Paso Robles Formation (Alluvial fans- QTp)

QTp consists of poorly consolidated to unconsolidated, poorly sorted, gravels, sands, silts and clays (Dibblee, 1950; Upson and Thomasson, 1951; Wilson, 1959; Miller, 1976; Berenbrock, 1988; Bright et al., 1992; Yates, 2010). QTp varies in thickness from 2,800-ft in the Santa Ynez subarea (Upson and Thomasson, 1951) 6.5 miles west of the San Lucas Bridge, to 700-ft in Santa Rita Valley (Dibblee, 1950; Miller, 1976) and thins westward where it pinches out in the eastern Lompoc plain (Dibblee, 1950; Upson and Thomasson, 1951; Miller, 1976).

QTp yields water to wells throughout the study area (Upson and Thomasson, 1951; Miller, 1976; Berenbrock, 1988; Bright et al.,1992) and is the principal water bearing unit in the basin near lake Cachuma and in the Santa Ynez uplands (Yates 2010).

Careaga Sand (marine-Tca undifferentiated)

Tca yields water and consists of massive, fine-to-coarse sand, with lenses of gravels and fossil shells (Dibblee, 1950; Woodring and Bramlette, 1950; Upson and Thomasson, 1951; Wilson, 1959; Evenson and Miller, 1963; Miller, 1976). Clay and silt beds are characteristically absent, and the uniformity in grain-size and presence of seashells distinguish it from the overlying QTp (Dibblee, 1950; Upson and Thomasson, 1951). Tca is often differentiated into the upper coarse sand *Graciosa Member (*Tcag) and the lower, fine sand *Cebada Member* (Tcac), which have been described in literature (Dibblee, 1950; Woodring and Bramlette, 1950; Upson and Thomasson, 1951; Evenson and Miller, 1963; Miller, 1976; Berenbrock, 1988; Bright et al., 1992). Tca thickness can vary from 450-ft to1000-ft (Upson and Thomasson, 1951), but is typically observed between 500-ft to 800-ft thickness in the Lompoc area, surrounding Lompoc hills, and in the Buellton area (Dibblee, 1950; Evenson and Miller, 1963; Miller, 1976). The Careaga Formation has been previously identified as an important aquifer within the SYRVGB (Hoffman, 2018).

<u>Aquifers</u>

Comprehensive studies of the water-bearing aquifers in the basin have been developed and published in numerous reports that are listed in the Geologic Data Sources section of this memorandum. The aquifers are typically categorized into two categories: Santa Ynez River floodplain alluvium and upland deposits formations (referred to in the Lompoc Area as an Upper Aquifer and Lower Aquifer) and are described in detail below.

Santa Ynez River Floodplain Alluvium – Upper Aquifer

In the Lompoc Plain, the Santa Ynez River floodplain alluvium is referred to as the Upper Aquifer, which consists of Qg, and Qa. It has been divided into 3 parts (Bright *et al.*, 1997) identified as the shallow, middle and main zones, described below.

The Shallow Zone has an average thickness of 50-ft. It is composed of river channel deposits (30-ft to 40-ft thick) and shallow upper alluvium deposits.

The Middle Zone is composed of the lower portion of the upper alluvium (moderately permeable sand and gravel lenses interbedded with deposits of fine sand, silt, and clay). The interbedded fine sand, silt, and clay deposits confine or partly confine the sand and gravel lenses in the western, central, and northeastern plains. The thickness of sand and gravel lenses range from 5-ft to 40-ft.

The Main Zone is located within the lower member of alluvium and consists of medium to coarse sand and gravel, separated from the upper aquifer zones by lenses of silt and clay. The Main Zone overlays the unconsolidated deposits that form the Lower Aquifer in the Lompoc plain. In the eastern and northwestern regions of the Lompoc plain, the silt and clay layers are less continuous or absent. As a result, groundwater moves freely between the zones of the Upper Aquifer. In the southern plain, the sand and gravel deposits in the main zone are absent. The fine sand deposits of the shallow and middle zones are also less continuous or absent (Upson and Thomasson, 1951).

Upstream of the Lompoc Plain, the Santa Ynez River floodplain alluvium is often referred to just as the river alluvium (no zonation). The thickness of the river alluvium generally averages up to 70-ft (Upson and Thomasson, 1951). Because this unit overlies consolidated deposits that are non-water bearing (see Section 1.1.2), the subflow in this unit is considered a part of the Santa Ynez River flow and is regulated by the State Water Resources Control Board as part of surface water rights.

Upland Deposits Formations – Lower Aquifer

In the Lompoc area, the upland deposits formations are referred to collectively as the "Lower Aquifer" and consist of undifferentiated Terrace Deposits/Older Alluvium (Qoa), Orcutt Sand (Qo) and the Careaga Sand (Tca). These deposits are present beneath the Lompoc uplands, the Upper Aquifer through the eastern portion of the Lompoc plain, and Lompoc terrace.

The Paso Robles Formation (QTp) forms the Lower Aquifer beneath the Lompoc uplands and east river area of Lompoc plain. The Graciosa and Cebada Members of the Careaga Sand (Tca) are present beneath the Lompoc upland and most of the Lompoc plain. However, the Graciosa Member generally is absent or unsaturated. Where present, the Graciosa Member of the Careaga Sand (Tca) is the main producer of ground water in the Lower Aquifer.

These same formations (Qoa, Qo, QTp, and Tca) also make up the aquifers in the Santa Rita Upland and Buellton Upland.

Geologic Formations Surrounding the Basin

Additional Tertiary-Mesozoic age typically non-water-bearing bedrock units are present within and surrounding the basin. These units are important because they contribute to the geologic structure (Figure 5) of the basin and define the limits of the water-bearing aquifer units by limiting groundwater flow due to limited or non-permeability, reduced or no storage capacity, or poor groundwater quality. These constraining bedrock units within and surrounding the basin are included in the geologic model described in Section 1.2 and are described below.

Tertiary-Mesozoic Rocks

Tertiary-Mesozoic Rocks are consolidated non-water bearing units, all of marine origin. They consist of the near-shore marine *Foxen, Sisquoc,* and *Monterey Formations*. The Foxen Formation consists of light gray or tan massive claystone, siltstone, and/or mudstone (Dibblee, 1950; Woodring and Bramlette, 1950; Upson and Thomasson, 1951). The Sisquoc Formation is massive to very thin bedded, white diatomite and diatomaceous mudstones, with basal massive fine sands (Dibblee, 1950; Woodring and Bramlette, 1950; Upson and Thomasson, 1951). The Monterey Formation, primarily known for its vast oil reserves, consists of variably bedded siliceous shale, diatomaceous mudstone, porcelaneous shale, chert, phosphatic shale, silty shale, limestone, and a basal clay altered tuff (Dibblee, 1950; Woodring and Bramlette, 1950; Upson and Thomasson, 1951).

2. GEOLOGICAL MODEL

2.1 MODEL USE AND INTENT

The detailed subsurface three-dimensional model was developed as a visualization and communication tool to convey the regional geologic setting and confining features of the basin to WMA and CMA GSAs, and the public, in accordance with SGMA. Additionally, the model will be used in concert with the Water Budget and the DMS to identify potential data gaps within the basin where additional data collection may be warranted. Furthermore, model elements may be exported to support subsequent technical studies conducted in the basin for incorporation into a SGMA compliant Groundwater Sustainability Plan (GSP), due to the California Department of Water Resources (DWR) in January of 2022.

2.2 MODELING APPROACH

Modeling Software

The software used for the model is Seequent's Leapfrog Works (Leapfrog), an industry-standard geologic modeling software, designed to view and manage surface and subsurface data, build complex geologic models, visualize hydrogeological systems, understand the impact of water use, and provide jurisdictional authorities with tools to convey complex topics to the general public (Seequent, 2020).

Model Domain

The geologic model domain boundaries (model extent) were selected to encompass the entirety of the WMA and CMA, and slightly overlapping the EMA to the east. Ground surface elevations were defined using a combination of publicly available digital elevation models (DEM). Next, quantitative measurements for geologic units exposed at the ground surface were imported using existing literature and publicly available geologic maps. Contacts between those geologic units (surface between two different rock types) were defined as erosional or depositional, as the designation augments the model assumptions and subsurface interpolations. Once the contacts were defined, the volume between those contacts were filled according to the depositional environment, age of the geologic unit, and localized structure to form a complete geologic model. The data used to interpolate and interpret the geologic surfaces generated in 3D are described in detail in Section 1.2.3. Leapfrog's interpolation algorithm and manual manipulation according to professional judgement were used to adjust surfaces, as appropriate. Structural elements were also incorporated from existing literature and publicly available geologic maps. The generated result is a detailed subsurface geometric rendering of the geologic contacts presented in the attached cross-sections.

Data Quality

Data quality objectives include verification of alignment with existing literature and available geologic maps; and coordination with the EMA GSA and consultant team to review and confirm alignment between the modeled CMA/EMA boundary (boundary). To facilitate model alignment at the boundary, data review, modeling approach discussion and data sharing was conducted. The consultant teams for the CMA and EMA provided boundary data packages for review. Each consultant team reviewed the data received, organized and validated the data, then incorporated the data into their model to assess modeled boundary alignment. Geologic formations from locations were reviewed in both models, confirming assumptions across the boundary.

2.3 GEOLOGIC DATA SOURCES

Various publicly available data were sourced for compilation and assessment prior to incorporation into the model, described in detail below.

Borehole Data

Publicly available well bore and well completion information was obtained from the California Department of Water Resources (DWR) online inventory, the Santa Barbara County Public Health (CPH) historical paper well records, the Santa Ynez River Water Conservation District, and from the California Department of Oil and Gas and Geothermal Resources (CA DOGGR) open file report (USGS, 2010).

The DWR online database consists of redacted well completion reports of varying quality, and map locations of varying accuracy. Available well completion reports within the study area were obtained from the DWR online database using the DWR Well Completion Report Map Application and incorporated into a secure relational database for the purpose of building the model. Once the data were compiled, assessed and validated for their intended use, they were incorporated into the DMS prepared for the basin. The available well records are accompanied by a longitude and latitude provided by DWR; however, many records are simplified, and locations are centered in their respective township and range quadrant, within approximately one square miles of their actual location. Well locations were updated manually in GIS software using assessor parcel numbers (APN), hand-drawn maps, addresses, and other location information available in the well records.

Available historical County EHS well records were obtained in paper format, the files were digitized, and pertinent data was extracted. Well records were evaluated for useful information and incorporated as appropriate into the model.

Additional stratigraphic interpretations from 694 Oil and Gas wells were collected in digital format from the (USGS, 2010). The well information was sourced from the CA DOGGR records. These wells were originally interpreted to model the Santa Maria Basin and provide depositional trends and structural evolution of the basin.

In total, 916 well records were used from the study area there to build the model, including 349 DWR, 396 CPH, and 171 CA DOGGR well records. Of the total well records used, 518 well records are within the WMA and 221 are within the CMA. The geologic formations were transcribed from the DWR and CPH well logs for import to the geological model while interpretations from CA DOGGR were imported as interpreted.

<u>Surface Topography</u>

DEMs were used to provide a best estimate for ground surface elevation across the model domain. The primary DEM is based on USGS's recently released regional FEMA LiDAR surveys related to 2018 post-fire surveys. This DEM was collected at 1-meter accuracy and represents a bare earth surface with trees and features removed. USGS standard 1-meter DEMs are produced exclusively from high resolution light detection and ranging (LiDAR). In areas where a 1-meter accuracy DEM is not available a 1/3 arc-second equivalent (approximately 10-meter accuracy) used instead.

All DEMs were sourced from the National Map (TNM) via the USGS.

- *U.S. Geological Survey, 20190930, USGS NED one-meter x75y384 CA SoCal Wildfires B4 2018 IMG 2019: U.S. Geological Survey.*
- *U.S. Geological Survey, 20190924, USGS 13 arc-second n35w121 1 x 1 degree: U.S. Geological Survey. Sources for Descriptions of Geological Formations*

<u>Surface Geology</u>

i The model is composed of publicly available geologic data from the Unites States Geological Survey (USGS). Interpreted surface geology was publicly accessed via the

USGS Mapview database tool. Surface geology is comprised from the following USGS Quadrangles:

- *CMA: Solvang and Gaviota Quadrangle, Zaca Creek Quadrangle, Santa Rosa Hills and Sacate Quadrangle, and Los Alamos Quadrangle.*
- *WMA: Lompoc Hills and Point Conception Quadrangle, Point Arguello and Tranquillon Mountain Quadrangle, and Lompoc and Surf Quadrangle.*

Subsurface geology was partially interpolated using surface contacts of geologic units, as well as structural data (dip and dip azimuth) present in each quadrangle. Subsurface geology was extrapolated from a combination of surface contacts and structural data points from the geologic quadrangle using Leapfrog software.

The major formations shown in Figure 2 are described in Section 1.1 and included in the attached stratigraphic columns (Figures 3 and 4).

Descriptions of Geological Formations

There have been numerous investigations of geological formations of the basin by others in the past, some of which date back to the 1940s. Some of the more comprehensive reports for this area include the following:

- *Geology of Southwestern Santa Barbara County, California: Point Arguello, Lompoc, Point Conception, Los Olivos, and Gaviota Quadrangles* (Dibblee, 1950)
- *Geology and Ground-Water Features of Point Arguello Naval Missile Facility Santa Barbara County California* (Evenson and Miller, 1963)
- *Geology and Paleontology of The Santa Maria District California. USGS 222* (Woodring and Bramlette, 1950)
- *Evaluation of Ground-Water Flow and Solute Transport in the Lompoc Area, Santa Barbara County, California* (Bright *et al.,* 1997)
- *Preliminary Report on Water Storage Capacity of Unconsolidated Deposits Beneath Lompoc plain* (Upson, 1943)
- *Geology and Water Resources of the Santa Ynez River Basin, Santa Barbara County, California: Water-Supply Paper 1107* (Upson and Thomasson, 1951)
- *Ground-Water Hydrology and Quality in The Lompoc Area, Santa Barbara County, California, 1987-88: U.S. Geological Survey Water-Resources Investigations Report 91-4172* (Bright *et al*., 1992)
- *Ground-Water Appraisal of Santa Ynez River Basin, Santa Barbara County, California: U.S. Geological Survey Water-Supply Paper 1467* (Wilson, 1959)

- *Development of A System of Models for The Lompoc Ground-Water Basin and Santa Ynez River* (Hydrologic Consultants, Inc., 1997)
- *Ground-Water Resources in The Lompoc Area, Santa Barbara County, California* (Miller, 1976)
- *Phase I Services, Preliminary Geotechnical Engineering Study, East Cat Canyon Oil Field, Sisquoc Area, Santa Barbara County, California* (Fugro Consultants, Inc., 2014)
- *Assessment of Groundwater Availability on the Santa Ynez Chumash Reservation* (Yates, 2010)
- *Digital tabulation of stratigraphic data from oil and gas wells in the Santa Maria Basin and surrounding areas, central California coast: U.S. Geological Survey Open-File Report 2010–1129* (USGS, 2010)

<u>Cross Sections from Previous Reports</u>

An important and useful resource to build the model was the large number of existing geologic information and cross sections from previous studies and reports conducted in the basin. The selected reports include the following:

- *Geology of Southwestern Santa Barbara County, California: Point Arguello, Lompoc, Point Conception, Los Olivos, and Gaviota Quadrangles* (Dibblee, 1950)
- *Geology and Water Resources of the Santa Ynez River Basin, Santa Barbara County, California: Water-Supply Paper 1107* (Upson and Thomasson, 1951)
- *Ground-Water Appraisal of Santa Ynez River Basin, Santa Barbara County, California: U.S. Geological Survey Water-Supply Paper 1467* (Wilson, 1959)
- *Ground-Water Hydrology and Quality in The Lompoc Area, Santa Barbara County, California, 1987-88: U.S. Geological Survey Water-Resources Investigations Report 91-4172* (Bright *et al*., 1992)
- *Geologic Map of The Zaca Creek Quadrangle, Santa Barbara County, California* (Dibblee, 1993)
- *Geologic Map of The Los Alamos Quadrangle, Santa Barbara County, California* (Dibblee, 1993)
- *Evaluation of Ground-Water Flow and Solute Transport in the Lompoc Area, Santa Barbara County, California: Water-Resources Investigations Report 97-4056* (Bright *et al*., 1997)
- *Development of A System of Models for The Lompoc Ground-Water Basin and Santa Ynez River* (Hydrologic Consultants, Inc., 1997)

- *Geophysical and Geotechnical Study Sewer Force Main Crossing, Santa Ynez River, Solvang, California* (Fugro West, Inc., 2007)

A total of 58 cross-sections from previous reports were digitized and imported into the model for visualization. The locations for the 58 cross-sections are included on Figure 6. The imported cross-sections were assessed for their agreement with model elements and used to validate the modeled surfaces, thicknesses and presence within the basin.

3. MODEL VISUALIZATIONS

Views from the model are presented as **Figures 2, 5**, and **6**. An aerial view of the outcropping geologic units and basin boundaries is presented as **Figure 2**. Generalized stratigraphic columns are presented as **Figures 3** and **4**. Cross-section views of the basin are presented in **Figure 5**. **Figure 6** provides an aerial view of modeled data, including well locations, cross-sections and geologic formations.

Figure 1: Site Location Map. Identifies basin location and geomorphic province information.

Figure 2: Geological Map and GSA Boundaries. Figure 2 presents an aerial view of the outcropping geologic units and basin boundaries. Areas of interest include Lompoc Terrace, Lompoc Plain, and Lompoc Upland and are included for reference purposes. The cross sections A-A' through G-G' are also shown on the figure.

Figures 3 and 4: Stratigraphic Columns (Shallow and Deep). These figures provide schematic stratigraphic columns with depths and short descriptions of each geologic formation.

- The shallow stratigraphic columns provide detailed descriptions for shallow formations **in the** WMA and CMA areas to the depth of the Tca (approximately 1,300 ft below ground surface).
- The deep column presents formation approximations from the surface to the Tm (approximately 9,000 ft below ground surface).

Figures 5: Geologic Cross Sections.

- **Cross-section A-A'** extends from west-to-east along the Santa Ynez River through the Lompoc Plane and intersects with Cross sections B-B' and C-C'. In this area consolidated formations form a westward plunging syncline which propagates through the WMA.
- **B-B'** is located on the west side of the WMA with a south-to-north orientation similar to sections C-C' through G-G'. Consolidated formations form a repeated syncline/anticline fold system that extends to the north of the model.
- **C-C'** extends through the middle of the WMA through the Lompoc Plain and Lompoc Upland and continue the syncline/anticline fold structure observed in cross section B-B'.
- **D-D'** is located near the northern boundary between the WMA and CMA and displays a similar fold structure to cross section B-B' and cross section C-C'.

- **E-E'** extends across the Santa Ynez River at the southeast boundary between the WMA and CMA. The southern limb of the central syncline is observed at the northern end of cross section E-E' along the north side of the Santa Ynez River. The middle and north portions of the section are mainly composed of consolidated rocks.
- **F-F'** transects through the CMA, south of Los Alamos. The central syncline continues through southeast of the model with the southern limb of the central syncline of consolidated rocks below the Santa Ynez River.
- **G-G'** is location on the east side of CMA which extends across the Santa Ynez River, through the City of Buellton and up through the Zaca Creek bed. Similar to cross section
- **F-F'**, the southern limb of the central syncline is located in the south below the Santa Ynez River and the northern anticline repeating in the north below Zaca Creek.

Figure 6: Available Data. Presents spatial distribution of available data resources incorporated into the model and potential data gaps, as described in additional detail below.

4. DATA GAPS

The model results will be used in concert with the Water Budget, the DMS and future additional technical studies conducted by others to identify potential data gaps within the basin and where additional data collection may be warranted. Data gaps may include lack of groundwater wells in portions of the basin, absence of ground surface elevation or groundwater measurement elevation for existing wells, inconsistent groundwater elevation measurements for a given well, long well screens that span multiple groundwater aquifers – providing insufficient or unreliable data, well screens that penetrate the river alluvium and do not represent principal aquifers, and other similar data gaps. Identification of data gaps within the model, paired with data gaps identified in other technical studies will be compiled and will inform recommendations for additional data gathering, as appropriate.

As presented on **Figure 6**, available data incorporated into the geologic model includes 58 cross sections from existing literature and previously published reports, and data from 1,439 unique well borehole locations. Cross-sections presented on **Figure 6** generally fit one of the three following categories:

- <u>Lompoc Plain:</u> the majority of available historical cross sections transect the Lompoc Plain along the Santa Ynez River (west-to-east) or crossing the river (south-to-north), within and the WMA.
- <u>Long cross-sections</u>: these transect the WMA (five) and CMA (two) from the Santa Ynez Mountains in the south, toward the San Antonio Creek Groundwater Basin in the north.
- <u>Short cross-sections</u>: transect the Santa Ynez River in the WMA (four) and CMA (three).

Although historical cross-sections are unavailable for the WMA/CMA boundary and are limited at the CMA/EMA boundary, well borehole data in those areas suggest that the model may sufficiently interpolate available borehole data, and data gaps in these two areas may not exist.

Well borehole data from the publicly available resources used in the model (i.e., well records from DWR, CPH, DOGGR, existing literature, and previously published reports) are distributed across most areas of the basin, with the following exceptions:

- An approximate 5.4 square mile (mi^2) area along the northern boundary of the CMA, northwest of the City of Buellton; and
- An approximate 26 mi^2 area within the Vandenberg Air Force Base, located in the northwest portion of the WMA, north of the Lompoc Upland and along the Pacific coastline.

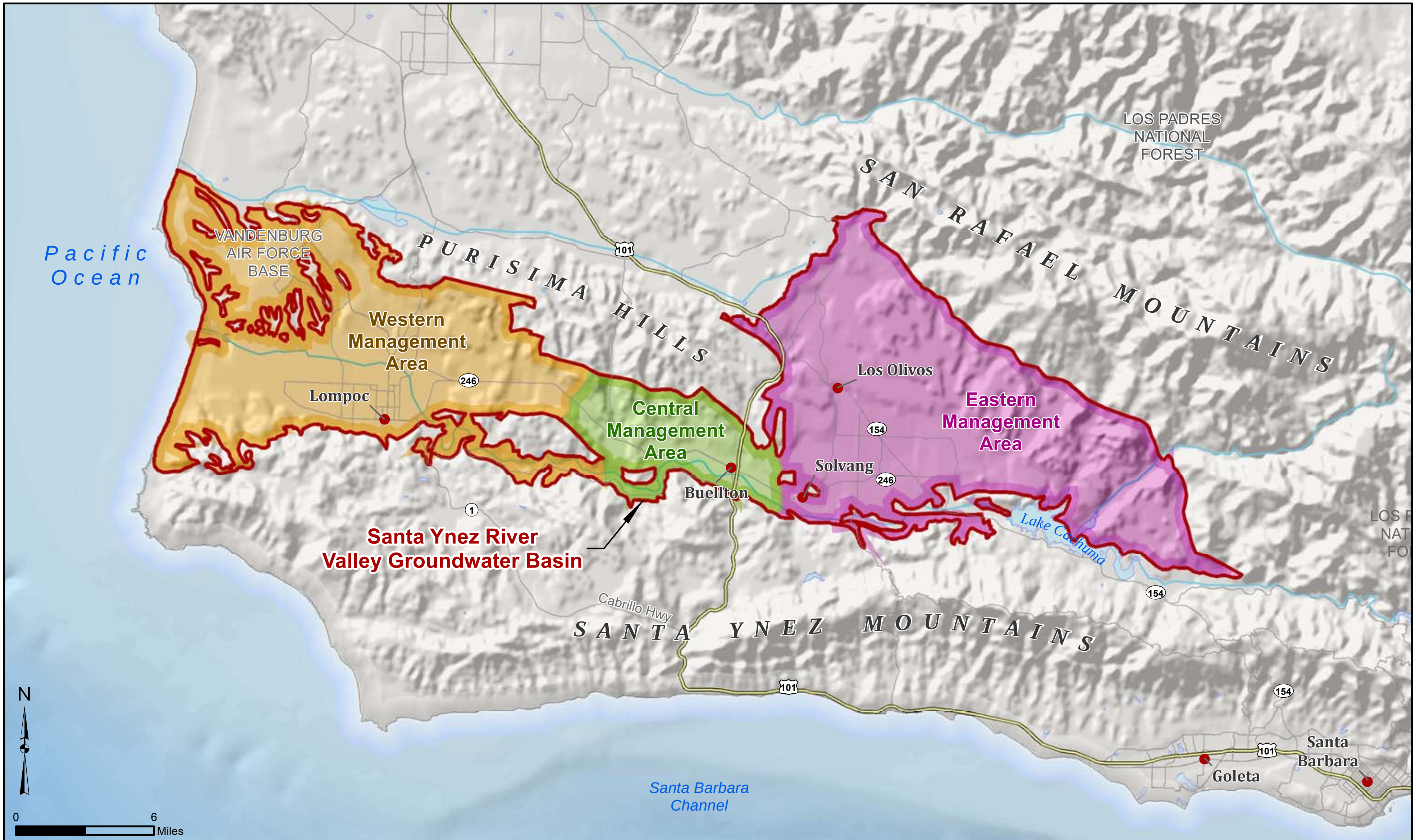
Historical borehole data for these two areas was not obtained from the publicly available resources searched and therefore, the lack of well borehole data in these areas may be considered a data gap. However, subsequent technical studies may determine that these areas are not necessarily vital to understanding and managing the groundwater flow regime of the SYRVGB, and additional data collection (advancement of well boring, or installation or well(s)) may not be necessary or recommended in these areas.

Additional data collected by the DWR endorsed SkyTEM program will be useful in validating and refining the geological structure of the WMA and CMA in the model. SkyTEM uses the Aerial Electromagnetic method (AEM) to obtain large scale geophysical data, useful for interpreting geology and the presence/absence of groundwater. The collected SkyTEM geologic data may be useful to refine modeled extent of geologic units to a depth of approximately 1,000 to 1,400 feet below the ground surface within the SYRVGW. The existing well borehole and cross-section data incorporated into the model and presented in this technical memorandum will be used to verify and interpret the SkyTEM survey results. The SkyTEM data may also be used to enhance subsequent technical studies, including numerical groundwater modeling to estimate the SYRVGB system, particularly the areas with data gaps (**Figure 6**), groundwater flow along the boundaries of the management areas, and along the Santa Ynez River and tributaries.

* * * * * *

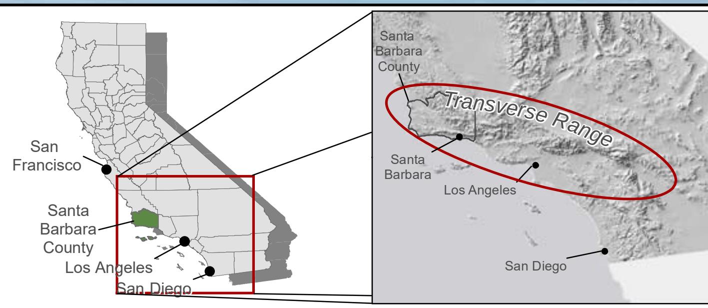
Attachments

Figure 1	Site Location Map
Figure 2	Geologic Map and GSA Boundaries
Figure 3	Shallow Stratigraphic Columns of Santa Ynez River Valley
Figure 4	Deep Stratigraphic Column of Santa Ynez River Valley
Figure 5	Geologic Cross Sections A-A’ through G-G’
Figure 6	Available Data Incorporated into Geologic Model



Explanation

- Santa Ynez River Valley Groundwater Basin
- Central Management Area
- Eastern Managment Area
- Western Management Area



Site Location Map

Santa Barbara County
California

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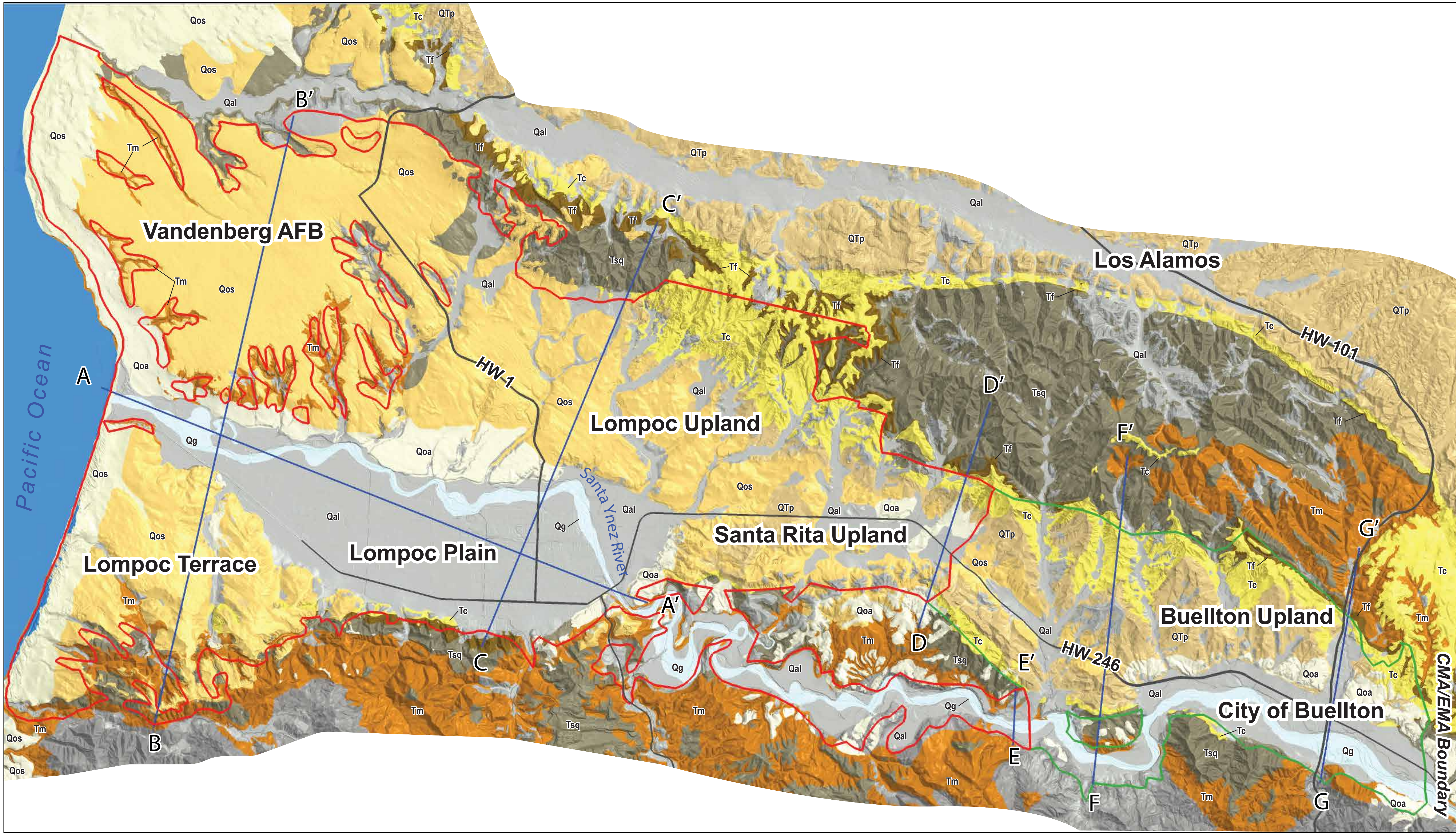
Figure
1

SantaBarbara-01\P:\GIS\Santa Ynez River Valley SGMA\Projects\2020 GW Model Tech Memo\Fig01_Basin_Wide_Map.mxd 4/29/2020 (Author: SMcKnight) 11:19:38 AM



Legend

- Cross Section Location
- Western Management Area
- Central Management Area

Model Geology

- River-Channel Deposits (Qg)
- Younger Alluvium (Qal)
- Older Dune Sands (Qos)
- Older Alluvium (Qoa)
- Orcutt Sand (Qo)
- Paso Robles Formation (QTp)
- Careaga Sandstone (Tca)
- Foxen Formation (Tf)
- Sisquoc Formation (Tsq)
- Monterey Formation (Tm)
- Tertiary - Older than Monterey

N

0 10,000 20,000 Feet

Geologic Map and Boundaries

Santa Ynez River Valley
Santa Barbara County, CA

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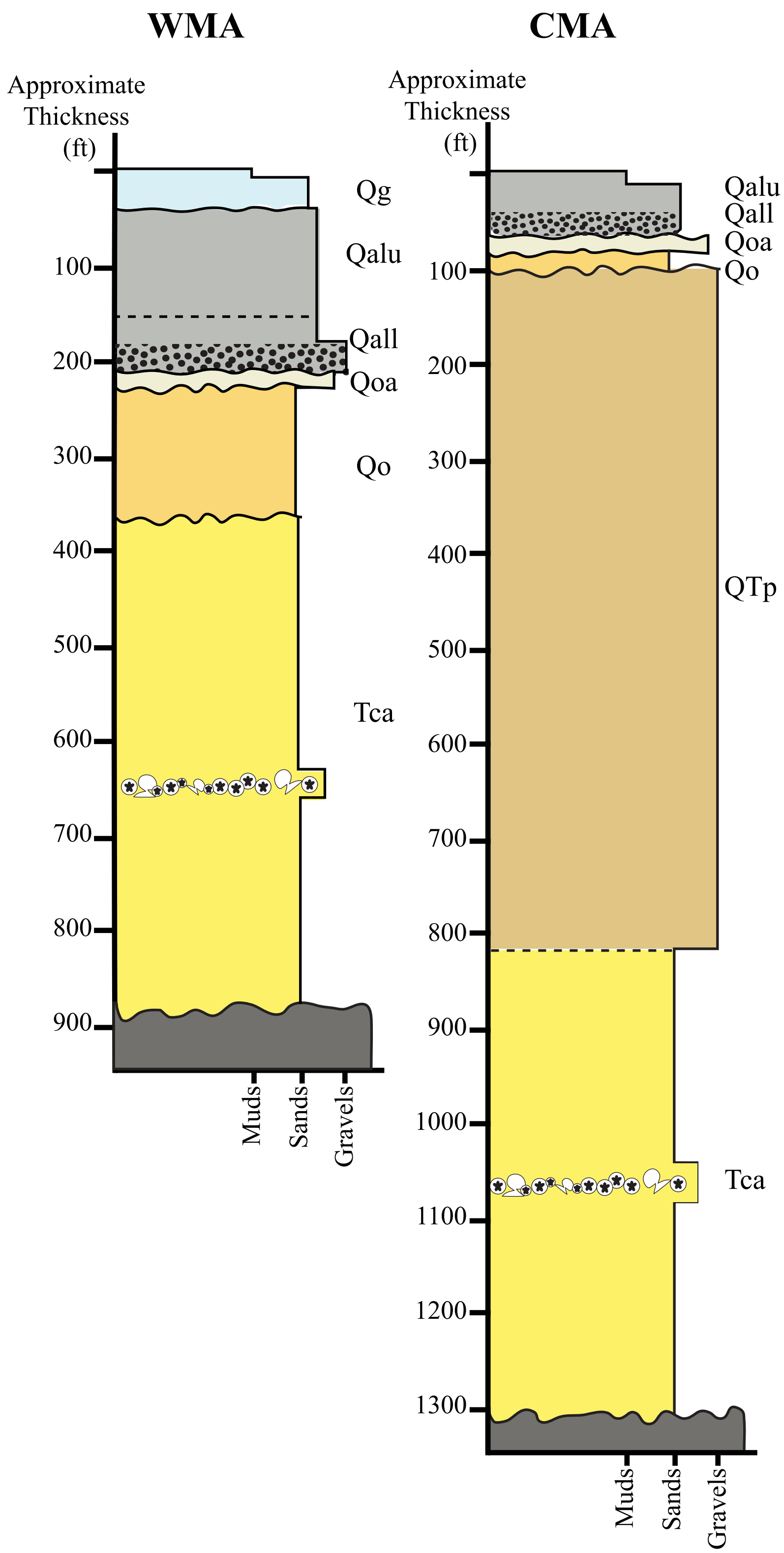
Figure 2



Formation Descriptions

River Gravels (Qg):
Coarse to fine sand, gravel and thin lenses of clay and silt; occurs in the modern channel of Santa Ynez River.

Young Alluvium (Qal):
Unconsolidated sands, gravels, silts and clays.
Upper Member (Qalu): Clay, silt and fine-grained sand and gravel stringers.
Lower Member (Qall): Cobbles, gravels, and medium to coarse grained sand. Cobbles/gravels concentrated at base.

Older Alluvium (Qoa):
Unconsolidated gravels, sand, and silt.

Orcutt Sands (Qo):
Unconsolidated, well sorted coarse to medium-grained sand and clayey sand with scattered pebbles/gravel stringers.

Paso Robles Formation: (QTp):
Weakly consolidated lenticular beds of clay, fine to coarse-grained sand, and gravels.

Careaga Sandstone (Tca):
Weakly indurated, massive, fine to coarse-grained sand, with local lenses of pebbles and seashells.

Legend

Qg
Qal
Qoa
Qo
QTp
Tca
Gravel Bed
Seashells
Undifferentiated Tertiary Rocks
Unconformity

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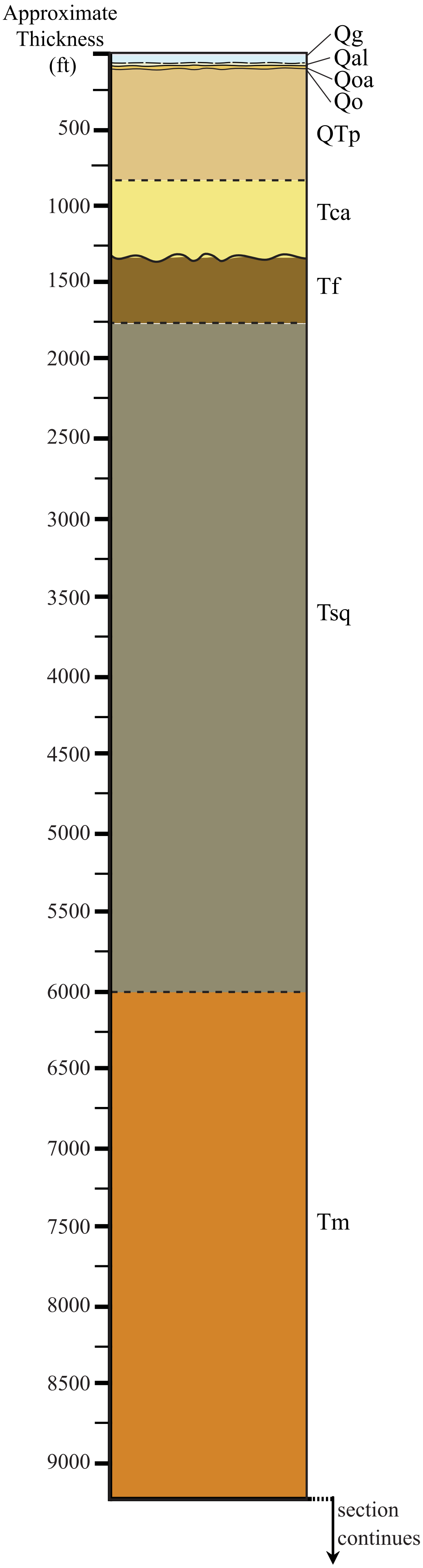
Shallow Stratigraphic Columns of Santa Ynez River Valley

Date:	April 2020	File No.:	
Project No.:	SB0959	Figure:	3



Formation Descriptions

River-Channel Deposits (Qg):
Coarse to fine sand, gravel and thin lenses of clay and silt; occurs in the modern channel of Santa Ynez River.

Younger Alluvium (Qal):
Unconsolidated sands, gravels, silts and clays.

Older Alluvium (Qoa):
Unconsolidated gravels, sand and silt.

Orcutt Sand (Qo):
Unconsolidated, well sorted, coarse to medium grained sand and clayey sand with scattered pebbles/gravel stringers.

Paso Robles Formation (QTp):
Weakly consolidated lenticular beds of clay, fine to coarse-grained sand, and gravels.

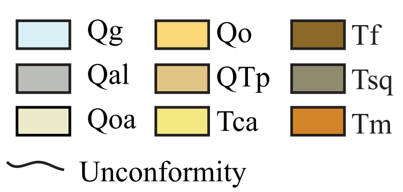
Careaga Sandstone (Tca):
Weakly indurated, massive, fine to coarse-grained sand, with local lenses of pebbles and seashells.

Foxen Formation (Tf):
Massive claystone/ siltstone/ mudstone.

Sisquoc Formation (Tsq):
Massive to very thin bedded, diatomaceous mudstone.

Monterey Formation (Tm):
Very well bedded siliceous shale, chert and diatomite.

Legend



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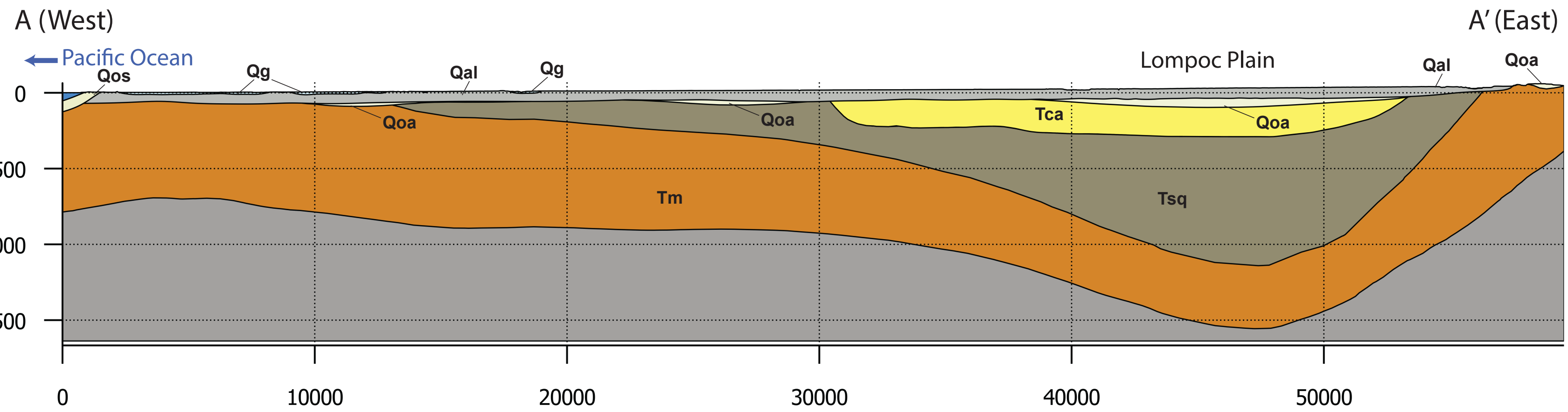
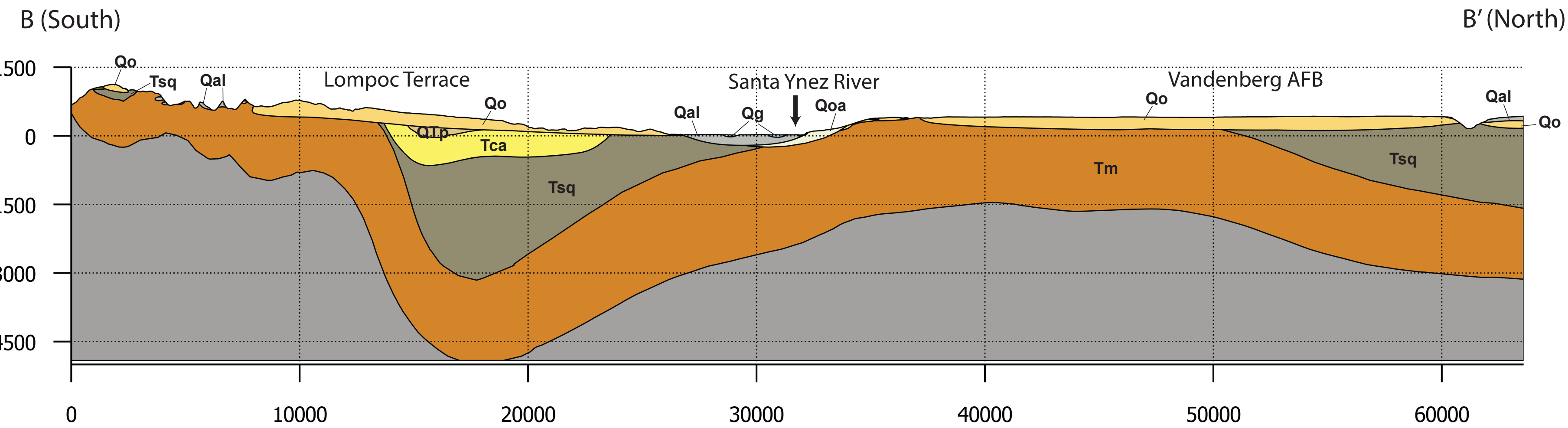
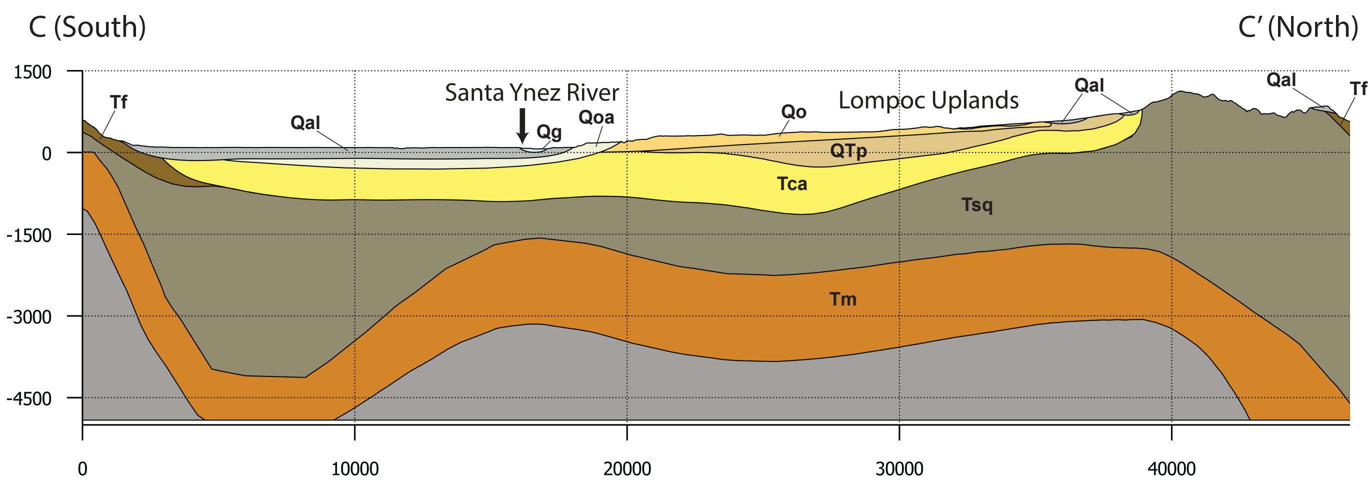
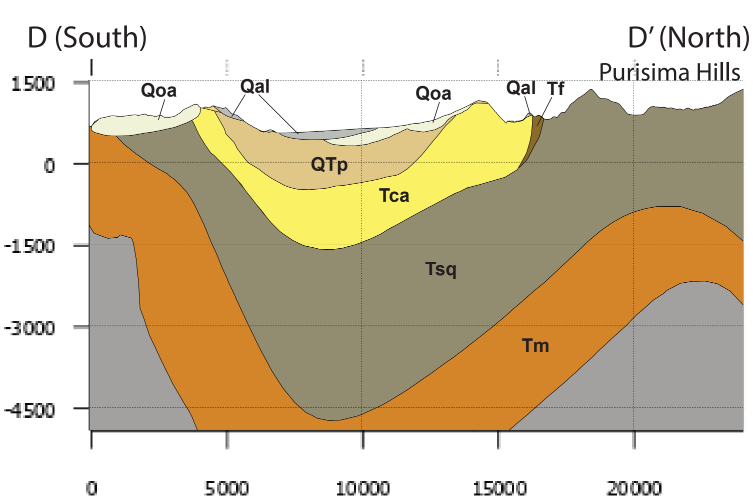
Deep Stratigraphic Column of Santa Ynez River Valley

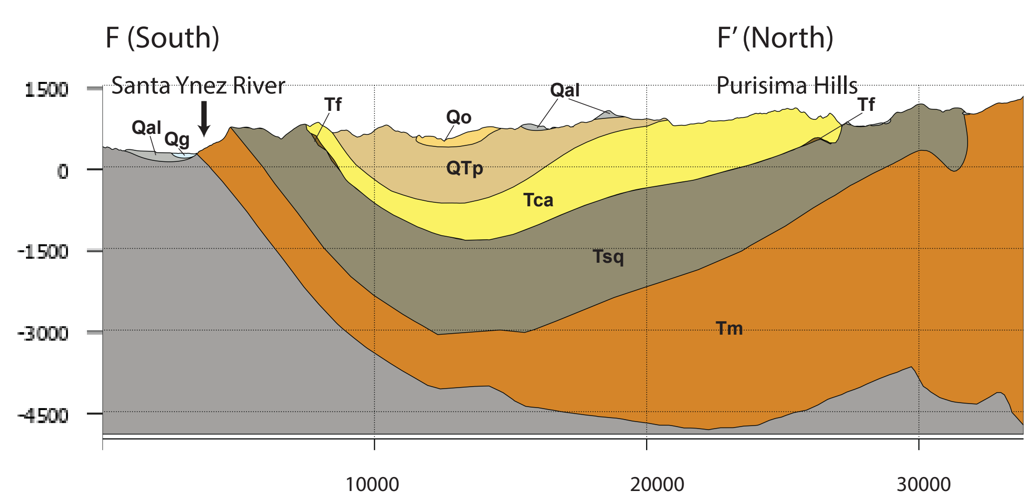
Date:	April 2020	File No.:	
Project No.:	SB0959	Figure:	4

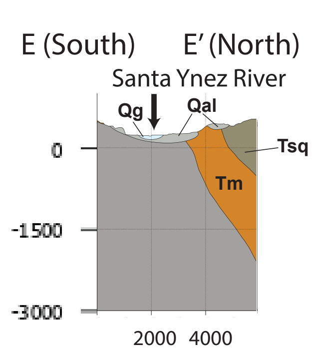


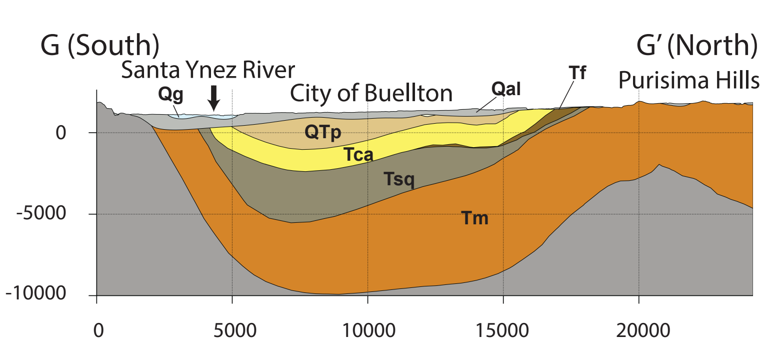




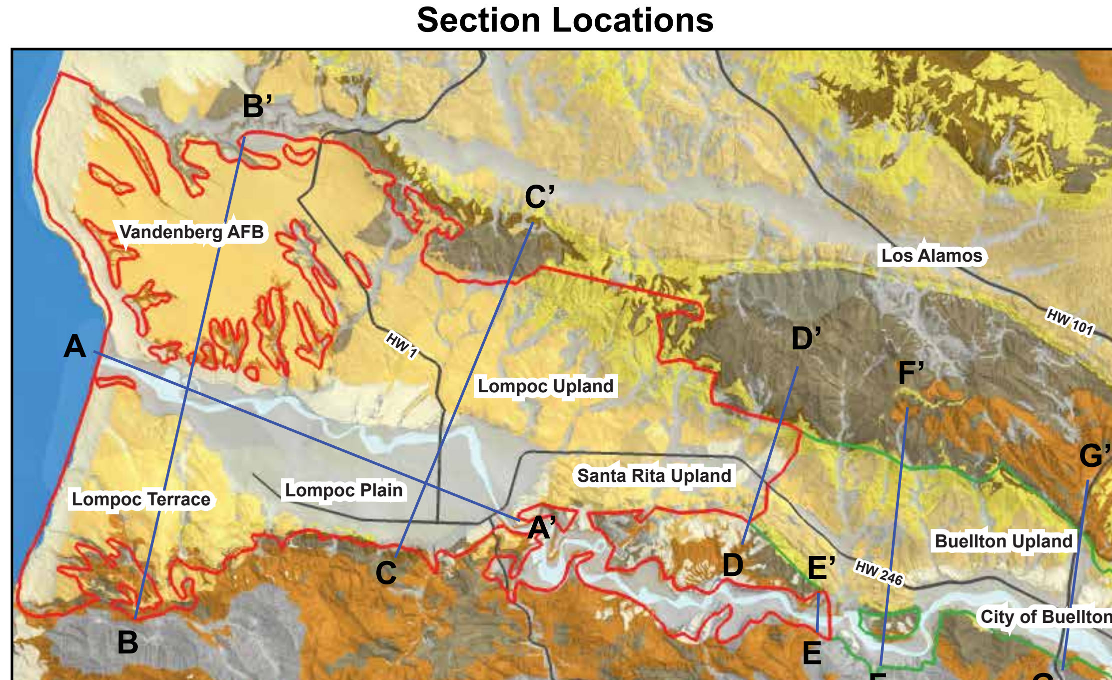








Section Locations



Geologic Model

River-Channel Deposits (Qg)	Orcutt Sand (Qo)	Sisquoc Formation (Tsq)
Younger Alluvium (Qal)	Paso Robles Formation (QTp)	Monterey Formation (Tm)
Older Dune Sands (Qos)	Careaga Sandstone (Tca)	Tertiary - Older than Monterey
Older Alluvium (Qoa)	Foxen Formation (Tf)	

Notes:
All images displayed at 2x vertical exaggeration
All units in Feet

Geologic Cross Sections A-A' through G-G'

Santa Ynez River Valley
Santa Baraba County, CA

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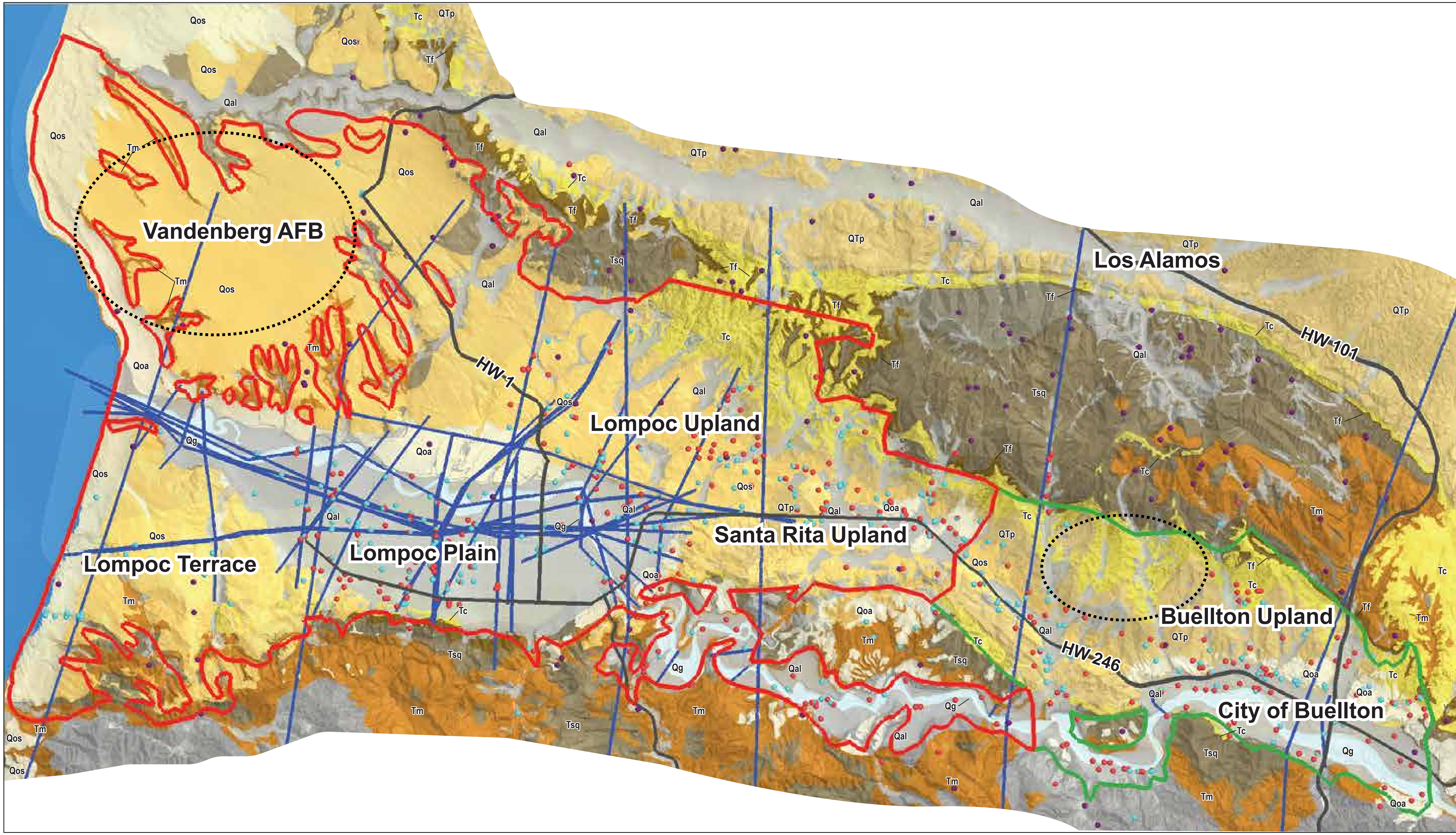
Figure 5



Legend

- DWR Log Location
- CPH Log Location
- OFR Log Location
- Cross Section from Previous Report
- Major Roadway
- Western Management Area
- Central Management Area

Model Geology

- River-Channel Deposits (Qg)
- Younger Alluvium (Qal)
- Older Dune Sands (Qos)
- Older Alluvium (Qoa)
- Orcutt Sand (Qo)
- Paso Robles Formation (QTp)
- Careaga Sandstone (Tca)
- Foxen Formation (Tf)
- Sisquoc Formation (Tsq)
- Monterey Formation (Tm)
- Tertiary - Older than Monterey
- Data Gap Regions

N

0 10,000 20,000 Feet

Available Data Incorporated Into Geologic Model

Santa Ynez River Valley
Santa Barbara County, CA

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Figure 6